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THE BIOLOGY OF THE RED-BACKED SALAMANDER (PLETHODON CINEREUS ERYTHRONOTUS GREEN).

M. ETHEL COCHRAN.

DISTRIBUTION.

Baird says, "Species of the genus *Plethodon* are found all across the North American continent." Boulenger makes the range of the subfamily Plethodontinæ North America, with possibly one species in the valley of the Rio de la Plata. Of the subfamily Plethodontinæ, Gadow states that it "is almost entirely American (with one species, *Speleopetes fuscus*, in Europe)," while Holmes says that "the Plethodontinæ form a large group which is mainly confined to America." In the last edition of his "Manual," Jordan gives the range of the family as "chiefly North America."

The "red-backed" salamander (*Plethodon cinereus erythronotus* Green) belongs to the Plethodontinæ and according to Jordan is confined to the eastern United States. Gadow says, "*Plethodon erythronotus* extends into Canada," while Boulenger would have it range in the eastern United States and Canada. Cope claims the species *Plethodon cinereus*, including all varieties, has an extreme range, being "found throughout the United States, east of the Mississippi River. It appears to be more abundant in the Middle States; its northern range is to the middle of Maine, Ontario and Michigan." Kingsley says it is the "most abundant salamander in the eastern United States."

Throughout Worcester County, Mass., this little salamander has proved very abundant. It is not an uncommon thing to find twenty or more during a short afternoon's walk. Every little wood has its dainty, shy, inhabitants who so easily may be overlooked.

HABITAT.

The tiny creatures are not visible to the casual observer, for on bright days they are always concealed beneath stones or fallen logs. Holmes says they are in damp situations under rocks or

decaying logs, while Montgomery found them near West Chester, Pa., "at all seasons, never in streams or boggy places, but in woods and hillsides beneath wood and stones, a strictly terrestrial species," Kingsley, on the other hand, claims "*Plethodon cinereus* is found everywhere in woods, under bark, logs and stone, in comparatively dry places." Miss Whipple speaks of its "being found far from any water supply."



OVERTURNING A STONE DISCLOSES A RED-BACK AT HOME. (Photograph by Dr. Miller.)

During a year's study of the species, they have been found in both damp and dry places, within five feet of a pond's edge and on rather dry, high slopes. In the daytime, they are always concealed. In one case, near a spring, a large sawdust pile that contained several planks furnished an abode for several salamanders.

One damp, dark day, when the rain was falling gently, three medium-sized individuals were found on the surface of the ground near stones from beneath which they had evidently come. In the same locality, five were found beneath stones; two were so placed that it seemed as if I had frightened them in before

aware of their presence. This idea was strengthened by finding one of the two in an ant's nest, a thing not found before. Of several specimens kept in the laboratory, in vivaria, a few would venture out of their retreats on dark days.

Rarely, if ever, are the salamanders found in treeless places, but they seem to have equal preference for pine, birch or mixed woods. All slopes, if shaded and of not too sandy a nature, seem to provide suitable dwellings.



The natural crevices beneath stones are utilized by the red-backs. (Photographed by Miss Gulick.)

It seems that no holes are made by the salamanders themselves, but that they utilize whatever is at hand. Allen noted holes, but was not sure whether the salamanders made them or not. In a pile of stones or in a sawdust heap, there are many natural openings connecting in labyrinthian fashion which are typical. In the vivaria kept in the laboratory, the pieces of moss were placed above a layer of sand and charcoal; a small dish of water was sunk to the level of the moss and the spaces between the pieces of moss, between the moss and sand, and between the "well" and sand were utilized by the red-backs as homes and highways.

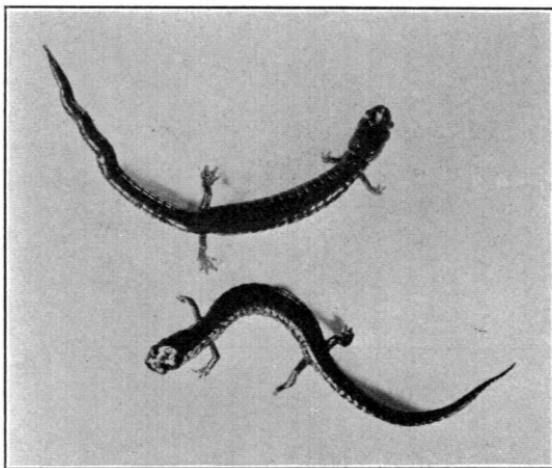
In one instance, where two specimens were found in rather soft earth, a well-defined hole was followed—it led by a short

gently-inclined path to a mass of rocks about a foot below ground where there were natural openings in all directions. The hole then appeared to be nothing but a natural opening worn smooth by use. Five other places were carefully studied where natural crevices seemed to be utilized.

The number of salamanders found under one object is variable; the most ever found was ten and countless times has only one been seen. There seems to be no evidence of their being or living in pairs during fall and early spring.

DESCRIPTION.

Kingsley calls these salamanders "the smallest in the United States." The largest specimen found measured 9.2 cm., while from 7.8 cm. seems to be the average length. The tail is about



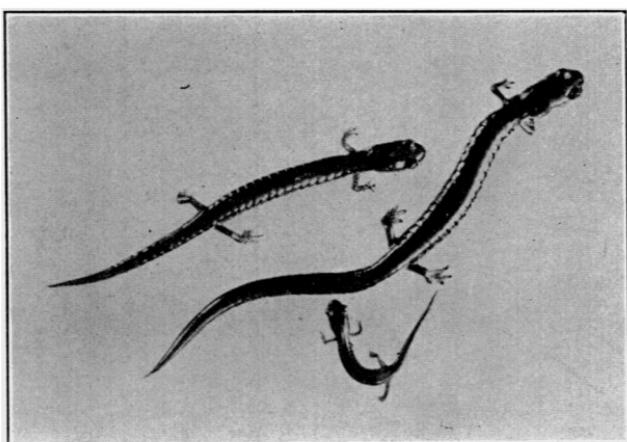
Red-backs. (Natural size.) (Photographed by the author.)

as long as the entire animal. Of two individuals, one, whose total length was 9.2 cm., had a tail 4.9 cm. long, while one 7.8 cm. long, had a tail 4.2 cm. in length. Jordan gives their total length as $3\frac{1}{2}$ inches (9 cm.). The following measurements give some idea of the relative length and width of the body: total length, 8.4 cm., tail 3 cm., costals 2 cm., width of head 5 mm., width of body 4 mm., dorso-lateral diameter 2 mm.

They are slender, with an almost cylindric body and a sharply pointed cylindrical tail. The legs are thin and weak and the

feet proportionately small. The anterior foot has three toes and an inner rudimentary one, while the posterior has four with one inner rudimentary toe. The body is not always lifted from the ground when the creature is walking—the tail never. *Spelerpes bilineatus* seems to be more slender than *erythronotus*, and when a dusky salamander (*Desmognathus fusca*) is about, the daintiness of a red-back makes it seem as clumsily built as an *Amblystoma*.

The most distinguishing feature of this species is the broad dorsal band of color that varies from bright, brownish-red to a sort of pale, dead-leaf brown. Age seems to make no difference



Red-backs. (Natural size.) (Photographed by Dr. Miller.)

in the color, nor has any sex differentiation been observed in fall and early spring. Two peculiar specimens found in company with several normal ones, in widely separated spots, were of a bright vermillion red, similar to the color of young *Diemyctylus*, over all the dorsal surface; the tail alone was a dark brown. It was probably a chance variation, as it seemed normal in every other respect.

The sides of the body and much of the tail are of a dark gray-brown finely flecked with silver spots that grow more numerous toward the ventral side where the color is almost white, varied with a few darker spots. The ventral part of the tail and legs is much darker than the belly, while the dorsal surface of the

legs is similar to the sides. The eyes are large for the size of the head, dark, iridescent, and very prominent. The nostrils are visible; the head is quite flat, the nose rounded, not pointed.

The skin is always moist and some amount of water is needed in the environment, for a specimen kept in a dry pasteboard box for a few hours was found in a much shriveled condition, dead.

The throat is in constant vibration which at times is very rapid; various counts were taken from seventy to one hundred and eighty a minute. The costals or costal folds, from sixteen to nineteen, are very easily seen. There seems to be no external character during fall and early spring to distinguish the sexes; in a few specimens dissected, the males were larger than the females.

ACTIVITIES.

The red-backed salamander is almost entirely nocturnal. Jordan and Kingsley mention this fact, while of *Autodax lugubris* Hallow, which belongs to a genus close kin to *Plethodon*, Ritter says it is entirely terrestrial and nocturnal.

This salamander is quick of movement. Often when first discovered, it is found in a graceful, curled position, and seldom moves unless touched. If annoyed, it glides rapidly, sometimes into crevices or holes and sometimes into the moss or leaves, where it lies quietly hidden. In this rapid gliding movement, the tail is lashed from side to side, as if aiding the fragile feet and legs.

It is a great climber—individuals in the laboratory climb up the sides of a glass vivarium with great ease, using the moist, adhesive abdomen, as well as the feet and legs. They have been seen to do this on rather dark days as well as in the evening.

Kingsley mentions finding them out of doors on a “spear of grass or coiled at the apex of a rachis of a fern at a distance of from twelve to eighteen inches above ground.”

There is a peculiar jumping habit common to the species—if one is held in the hand, a foot or more above the moss floor of a vivarium, it seems to gather itself together into a coil, and using its tail as an aid, it springs lightly to the moss. The whole process is indescribably quick. Kingsley says it “leaps by sudden unbending of the coiled body like some caterpillars.”

The red-back's activities in the water are interesting. Jordan says it "rarely or never enters water." Miss Whipple has described it well: "Although certain lungless species may be more or less aquatic, their activities, even in water, are terrestrial. Various species will at first, when in an aquarium, swim to the surface, then around and around the edge of the aquarium as if seeking a means of escape, but at the instant active swimming ceases, the body sinks clumsily and heavily to the bottom, where they remain until disturbed or until another effort is made to escape. Lungless forms show on the whole little power to adapt themselves to aquatic life. Most are terrestrial in habit, some, *Plethodon cinereus* and *Plethodon glutinosus*, being found far from any water supply."

"The nares close as soon as the animal is submerged in water and remain so as long as the animal is in water. In a few cases, there were attempts at a feeble bucco-pharyngeal respiration, but even then the external nares were closed and water was drawn in and expelled through the slightly opened mouth."

Salamanders in the laboratory seem able to endure extreme cold, for in a vivarium the water was found with a thick coating of ice, but the salamanders were apparently unaffected.

The latest date of finding a salamander out of doors in the fall of 1909 was November 13. The first specimens this spring (1910) were found on March 20, on a warm, southern slope free from snow. At this time there was still much ice and snow in the woods all about. In midwinter, Montgomery says the salamanders are found deeper in the ground.

FOOD AND FEEDING HABITS.

Regarding the frogs, salamanders, etc., Dr. Hodge says in "Nature Study and Life," "with one or two exceptions . . . they are all valuable insect destroyers, each for its peculiar haunts; they should be generally protected and utilized as beneficent forces in nature."

The red-back, like other amphibians, prefers live, moving food. On several occasions, bits of meat placed in the vivarium remained untouched for days and became covered with mould while if a piece were moved before a salamander, it was taken

eagerly. Small wriggling earthworms are enjoyed. In one case, a small toad tadpole was offered to a salamander whose attention was so attracted at once by the struggles of the tadpole that it promptly ate it. A companion at the same time ate two tadpoles. Small insects are captured and eaten with avidity.

A moving object is noticed very quickly. The salamander will follow it fixedly for a moment, then, with gaze still upon it, creep slowly after until close at hand, when a rapid spring is made for it. Often it appears to have difficulty in swallowing food—the eyes close as several slow gulps are made and sometime elapses before another portion is taken. No use of the hand in feeding has been noted, as is commonly seen in toads and frogs.

As a means of determining the kind of food taken in nature fifteen stomach-contents were examined. The salamanders came from several widely separated districts.

In general, specimens taken in the morning showed fuller stomachs than those taken in the afternoon.

The following specimens were found in the fifteen stomachs examined: Ants of several kinds, beetles of several kinds, bugs, caterpillars (cut-worm), centipedes, earthworms, fleas, flies of several kinds, maggots (rat-tail), midges, mites, mosquito wiggler, plant lice, plant remains, pseudo-scorpion, slugs (*Limax*), spiders, spring-tail (*Thysanura*), sow-bug, wasp-like insects.

Below is given a list of the contents of five stomachs that may be taken as typical.

A salamander captured May 17, 1910, at four P.M. in a saw-dust heap near a spring, Auburn, Mass., contained: four snout beetles, one yellow ant, one small spider and ten mites.

A salamander found under a stone in an ants' nest, April 28, 1910, in the afternoon at Auburn, Mass., contained: one earthworm (2.75 cm. long), two mites, two small beetles, and three maggots that were probably young ants.

A salamander found at Holden, Mass., at eight A.M., on April 27, 1910, contained: one earthworm (3.5 cm. long), one centipede, one black fly, one spider, one cutworm, one ichneumon maggot (probably from the cutworm), one pseudo scorpion, one sow-bug, and one unknown insect (which had eaten two small snails).

A salamander found on the afternoon of November, 11, 1909, at Gates Lane, Worcester, Mass., contained: three slugs (*Limax*, 1, 4, 5 mm. long respectively), one plant louse, one small worm, and plant remains (probably accidental).

A salamander captured in Norcross Woods, Worcester, Mass., at eight A. M., May 9, 1910, contained: one earthworm (2.2 cm. long), one brown spider (3 mm. long), two mites, one beetle, one spring-tail, one mosquito wiggler, one *Syrphus* fly, and plant remains.

ENEMIES.

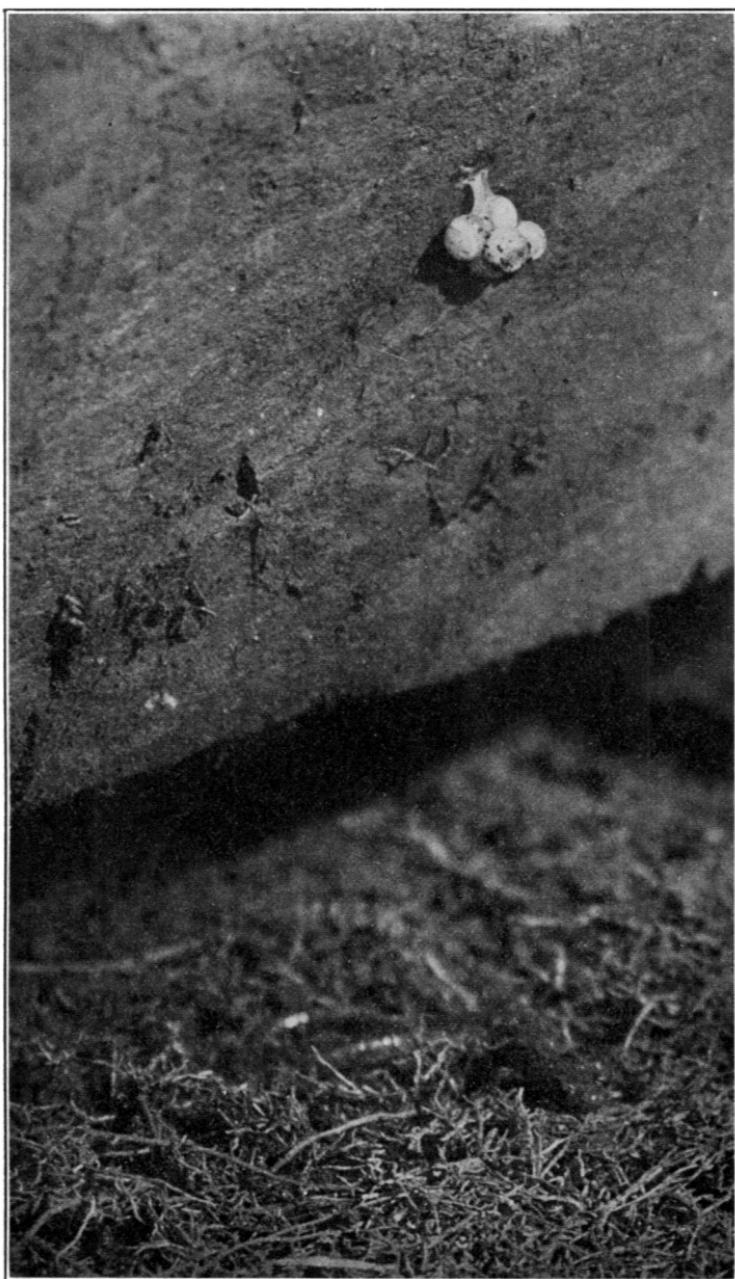
Snakes undoubtedly are great enemies of the salamanders. In a study made in Pennsylvania, Surface found that salamanders formed a large part of the diet of some snakes. The ribbon snake or striped garter snake (*Thamnophis saurita*), which belongs to the eastern United States and likes to live in shady, narrow, watered valleys, preys upon *beneficial* batrachians. "In four specimens containing food, four salamanders were found, two of which were *Plethodon cinereus*; 37.5 per cent. of the food of this species of snake was found to be salamanders." The common garter snake was found to destroy toads and salamanders among which was *Plethodon cinereus*. The water snake (*Natrix sipedon*) and the grass snake (*Liopeltis vernalis*) also were found to eat the red-back among other salamanders.

Ditmars states that the following snakes feed on salamanders, among which it is reasonable to include the red-back, as their haunts are much the same: ribbon snake (*Eutemia saurita* Linn.), mud snake (*Seminatrix pygaea*), brown or DeKay's snake (*Storeria dekayi* Hol.), green or grass snake (*Liopeltis vernalis*), eastern and western ringed-necked snakes (*Diadophis punctatus* Linn. and *D. amabilis* B. & G.).

A hungry, half-grown bull-frog ate a good-sized salamander with evident relish and a purple grackle treated one like a worm, beating it and breaking it with his bill before eating it.

PROTECTIVE DEVICES.

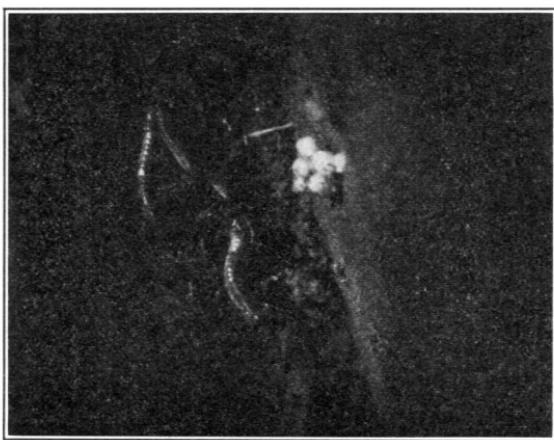
Plethodon cinereus erythronotus, when annoyed, yields a colorless, glutinous secretion from its tail. A Californian salamander, *Plethodon oregonensis*, was found by Miss Hubbard to yield



An upturned stone, showing cluster of eggs, manner of attachment and brooding salamander. (Natural size.) (Photographed by Dr. Miller.)

on the tail an abundant poisonous fluid which did not prevent snakes from eating it. Easterly has written of the large granular glands of this salamander which are poisonous, but to what he does not state.

Baird speaks of the genus *Plethodon* whose skin exudes a highly glutinous secretion, but he makes no statement of its nature. Gadow says: "Numerous experiments have shown that the poison of toads, salamanders and newts is capable when injected, of killing mammals, birds, reptiles and even fishes, provided of course, the dose be proportionate to the size of the animal. Small birds and lizards succumb as a rule in a few minutes; guinea-pig, rabbits and dogs in less than an hour. This poison of amphibia is not septic, but acts upon the heart



Raised stone showing pair of red-backs with eggs. (About one half natural size.)
(Photographed by Dr. Miller.)

and central nervous system. Some authorities hold that the poison is an acid, others regard it as an alkaloid."

The fluid from a red-back's tail is very sticky when placed in the mouth; after a short time, a slight biting sensation is felt for a few moments.

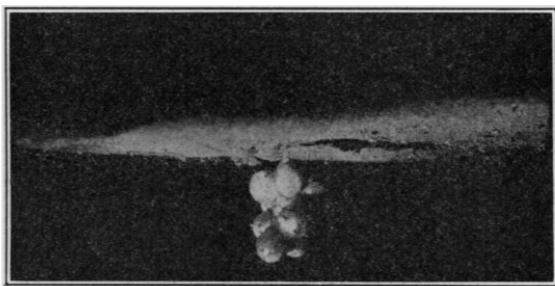
Several of the salamanders taken from their native haunts had every mark of possessing a regenerating tail. In one case, the tail had been cut or broken off nearly to the hind legs and the bud of a new one had grown out about a quarter of an inch.

Miss Towle found that *Plethodon cinereus* had the regenerative power also in the limbs.

Of *Plethodon oregonensis*, Miss Hubbard says it practices "autotomy only as a last desperate resource, and but in one region (directly behind the anus)." But when in two or three instances, the tail of a red-back has been held by forceps, the tail has come off very easily and in no particular region. Those found wild with incomplete tails appeared to have been broken in no particular joint. This salamander has not been observed thus far to snap or bite for protection.

INTELLIGENCE.

The red-backs are easily tamed, and will learn to eat food when offered on a splint. They object to being handled even after they have been in captivity a long time, probably because of the unpleasant warmth and dryness of the hand.



Cluster of eggs attached to a stone. (Two thirds natural size.) (Photographed by Dr. Miller.)

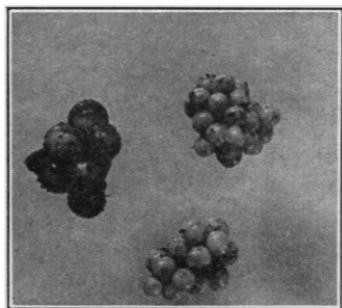
They appear to be very quick of hearing. Abbott, among other statements about the salamanders, mentions "their quickness of hearing." When undisturbed in their haunts, a whistle, clap of the hands, or a speaking voice sends them away. Abbott is of the impression that the salamanders give evidence of greater intelligence than the toads or frogs. His efforts to prove them possessed of cunning were not successful.

REPRODUCTIVE HABITS.

Baird writes of the genus *Plethodon*, "The eggs are deposited in packages or aggregations, in moist situations, under stones

and logs, not however, in the water; and the larvæ lose their branchiæ at a very early age."

Montgomery describes one finding of eggs: There were five eggs under a stone in July with an adult female curled about on guard. The eggs were large, enclosed in gelatinous envelopes, and curled about a large, nearly spherical yolk mass.



Eggs of dusky salamander (two clusters at the right), and red back (one cluster at the left.) (Natural size.) (Photographed by the author.)

Miss Sampson says, "*Plethodon* lays its eggs on land."

Ritter and Miller describe the eggs of *Aurodax lugubris* Hallow, a Californian salamander closely related to *Plethodon*. They are attached singly to the under surface of stones. In one instance a female with fifteen eggs was found under a platform in front of a barn, in dry earth next the foundation wall. The eggs are laid in

July, are about 6 mm. in diameter and hatch in fifty days.

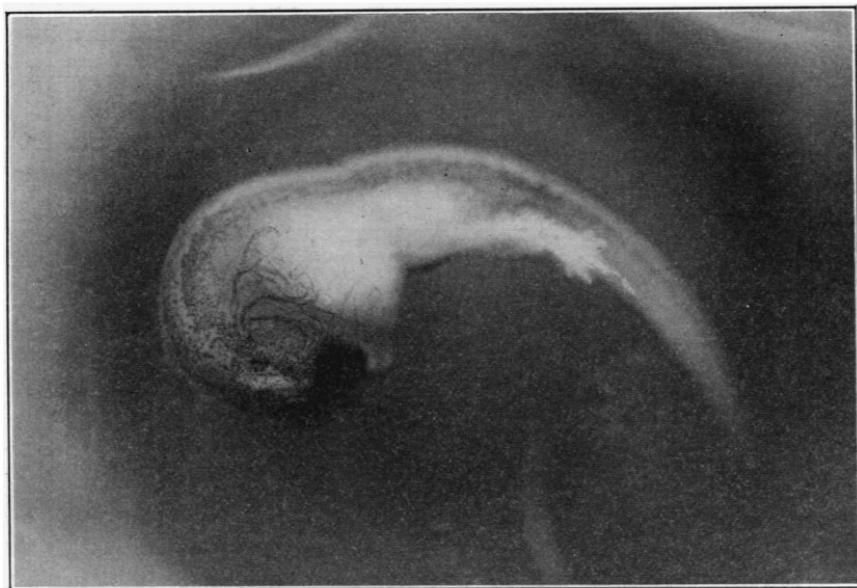
During the summer of 1910, eggs of the red-backed salamander were found first on July 5. From then until the latter part of August, eggs were found. They are in the ordinary habitats beneath stones and logs. The stones are always those deeply set into the ground in close contact with it, probably because there the atmosphere is moist.

The eggs, from five to nine in number, are in grape-like clusters attached to the under surface of stones or logs, unlike those of *Spelerpes* and *Autodax lugubris* Hallow, which are attached singly. One pedicel supports a cluster. This pedicel is tough, white, and seems made of separate threads closely stuck together; it resembles the tough, outer membrane covering each egg. There is no uniform arrangement of eggs in the cluster.

The egg of the red-back is spherical, 5 mm. in diameter, has a prominent yolk and considerable transparent jelly. On the outside is a thin, tough envelope to which particles of earth and leaves readily adhere.

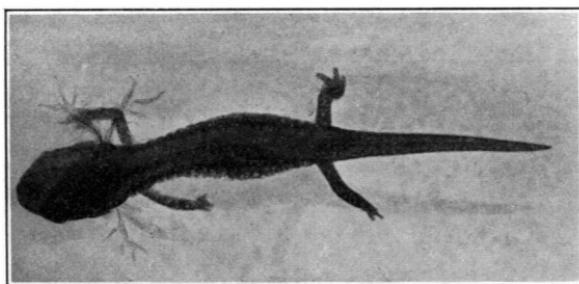
The embryo is coiled about the yolk. None were seen in

young enough stages to note the first appearance of color, but the red-brown of the dorsal stripe is visible at an early age.



Embryo red back, age unknown. (Enlarged about six times.) (Photographed by Dr. Miller.)

With each cluster of eggs, there was always one or two adults. Dissection showed that when there was one only, it was a female,

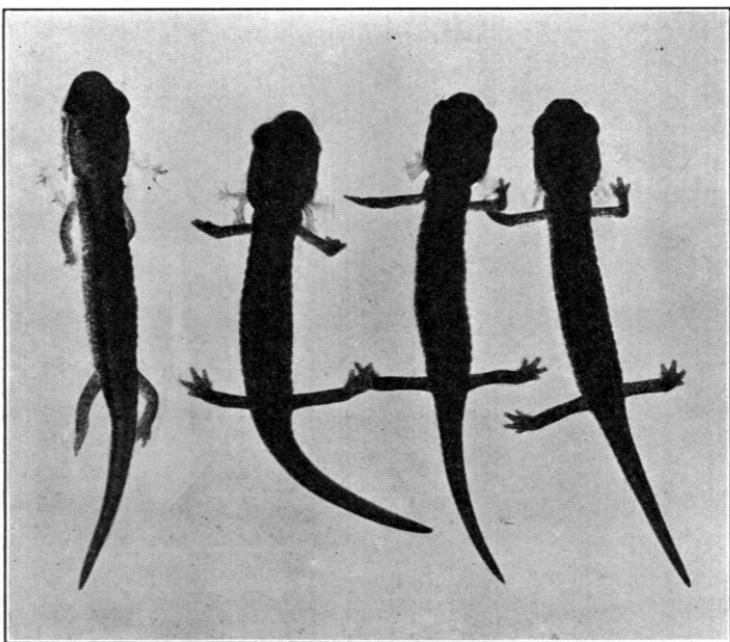


Embryo red-back taken from egg some days before time for hatching, showing the three pairs of gills. (Enlarged three times.) (Photographed by the author.)

when two, they were male and female. There is, accordingly, no evidence that the male takes any active part in the care of

the eggs in this species. The egg cluster is always so attached that one of the adults may coil its body about it. Sometimes a crevice beside a rock is utilized, the eggs, attached by the pedicel to a root or stone above, swinging loose. This brooding by the adults doubtless serves the double purpose of providing moisture and securing protection from insects.

Several attempts were made to transfer a parent with a cluster of eggs to the laboratory, that the development and hatching



From left to right: four embryos from the same cluster of eggs, one removed from the egg, one hatched about twelve hours, one about six hours and one about twenty-four hours. (Magnified three and one half times.) (Photographed by the author.)

might be observed. Damp moss was tried but it invariably moulded. A small jar kept moist with a wad of water-soaked cotton proved no better. Then, because the air of the laboratory seemed so disastrous, it was suggested opening the bottle, in which the eggs were brought from the field, upside down into an overturned sterile jar. Within the jar, the eggs were placed on a strip of filter paper that was so placed on a piece of glass

above a dish of water that it was constantly wet. No mould appeared, the moisture was constant, and the eggs developed.

An embryo just out of the egg is 2 cm. long; the gills are present but not quite so large as they are a day or two earlier. The head seems larger compared with the rest of the body, than in the adult stage. There is a large quantity of yolk visible which persists for several days.

In this cluster of eight eggs, five were allowed to hatch normally, three were opened for pictures. The hatching of the five covered a period of twenty-four hours. The actual process of hatching was not observed.

There is a small amount of jelly and membrane left; this was noted both in the laboratory and in the field where nests were under observation. Beneath one stone, the pedicel and gelatinous substance was observed after the eggs had hatched. It had turned dark and was tough and leathery.

The embryos just out are very active and show several characteristics of the species. Salamanders, less than a day old, avoid water, wriggle if annoyed and cling to the surface of the glass jar.

The gills shrivel rapidly; at the end of twenty-four hours, there are but mere stubs.

SUMMARY.

In summing up the results of the observations reported above, the writer makes the following statements:

1. The red-backed salamander is found throughout all the eastern United States and Canada.
2. It lives beneath stones and logs, ranging from rather dry to wet places.
3. It is a small salamander, usually about three and one half inches in length.
4. It is almost entirely nocturnal. It is quick of motion and a climber; it cannot live in water.
5. The food consists mostly of live insects, larvæ, worms and spiders.
6. Snakes and frogs are probably its greatest enemies.
7. The protective devices are autotomy and the secreting of a viscous fluid from the tail.

8. The eggs are laid beneath stones in July and early August. One of the parents, usually the female, broods them. The young hatch with three pairs of gills which shrivel in about a day.

My acknowledgments are gratefully given to Dr. Clifton F. Hodge for suggesting the problem, for his active interest and help during the year, to Miss Louise Gulick for aid in collecting specimens and photographic work, to Mr. William T. M. Forbes for help in identifying insects, and to Dr. Newton Miller for his excellent and painstaking work in photography. I also wish to thank the many people, who by their interest, advice and criticism have aided in the work.

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